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ABSTRACT

This paper is intended to provide a basis for discussion about staff development in the mathematics education community. It is directed to those who plan staff development programs intended to improve elementary mathematics teachers' classroom practice. Discussion includes the importance of establishing program goals and considerations of the knowledge base of teachers attending the staff development program. How teachers learn, their stages of development, the amount of administrative support they receive in their schools, and the teachers' sense of efficacy are also stressed as important to program planners. Included are 23 references. (DC)

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Staff Development for Mathematics Teachers:

Assumptions to Consider

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Staff Development for Mathematics Teachers: Assumptions to Consider

Introduction

Twenty years ago I was a teacher education student completing my preparation to become a teacher of secondary school mathematics. When looking back over such a long period of time, one's memories are naturally imprecise; however, one thing that always comes to mind when remembering those days is the amount of excitement, controversy, discussion, argument and awareness about mathematics teaching that was a part of our everyday discourse. The "New Math" era was still much in evidence in Ontario at that time; and, in spite of the criticisms that have been levelled at those who designed and promoted the innovative curricula of the period, at the very least the whole movement did focus public and professional attention on mathematics and mathematics teaching. Similarly, the recent publication by the National Council of Teachers of Mathematics (NCTM) of Curriculum and Evaluation Standards for School Mathematics (1989) will hopefully act as a catalyst for such important discussions. In my view this result would be just as significant as any specific changes that might occur because of the report itself. A heightened awareness of the need to examine practice and generate a national enthusiasm for the field of mathematics education is a necessary first step if any lasting changes in teaching practice are to occur.

Although necessary, an awareness of the need to reflect on practice is hardly sufficient to produce changes in well entrenched patterns of teaching. If we have learned anything from the ultimate failure of the curriculum reform efforts of the past it is that teachers must be considered to be a crucial part of the change process. When all is said and done the only people who can effect a change in classroom practice are teachers. Regardless of what kind of initiatives are undertaken by administrators and what kind of

plans are put in place to change the way that teachers teach, it is the teacher who must finally decide how to teach in his or her own classroom. The teaching force now in place has a vision of teaching mathematics that is definitely at odds with the one put forth by the Standards (1989). The danger of these standards ending up as more rhetoric than reform is a real one; and, specific steps need to be taken if they are to be used as a springboard for educational innovation. Consequently, I think that a significant aspect of the debate that should be part of the discussion of the Standards (1989) ought to focus on staff development and how, in fact, practising teachers can be encouraged and properly prepared to change their practice.

After a significant amount of reading in the area of staff development it seems to me that only one assumption appears to be agreed upon by all: The traditional one-shot teacher development day workshops do not produce any lasting change in classroom practice. If we assume that successful staff development is a process (as opposed to an event) that does produce such a change, then how can successful staff development programs be designed? Unfortunately, the specification of the kind of program that would produce a permanent change in teaching practice is by no means clear. This paper is intended to provide a basis for discussion about staff development in the mathematics education community. In particular I would hope that it will stimulate those involved in the planning of in-service and other kinds of staff development programs to examine in a critical way their assumptions about staff development; and, how these assumptions affect the design of staff development programs intended to meet the goal of improving elementary mathematics teachers' classroom practice.

These assumptions could be roughly divided into two broad categories. One category would consist of those factors involved with program content and delivery systems such as a discussion of the knowledge base required for teaching elementary mathematics; the view of teacher learning that is presumed by the staff developer; or, whether the plan should use mentor teachers, peer coaching or summer institutes as part of the development

program. The other category would involve assumptions about the organizational structures of schools that work to inhibit or enhance teacher development, such as administrative support; the provision by the schools of a mechanism that would allow for the long term follow-up support of teachers; or, how the norms of collegiality within a particular school setting might impact any staff development plan. Some factors, such as the goals of the program or the view of teaching that the program seeks to promote, bridge both of these areas and will be considered wherever it seems most logical to do so. In any event the discussion will be more conceptual than prescriptive because the details of any such plan are highly context dependent.

Program Goals

It is impossible to plan a staff development project unless the goals that the program is being designed to achieve are considered (but not necessarily fully or rigidly specified) at the outset. Such a consideration calls into question just what we mean by improving the teaching of elementary mathematics; and, our ability to specify what would count as an improvement hinges on our view of what good mathematics teaching would be. Given the research on what much contemporary mathematics teaching looks like, with the emphasis on rote memorization of algorithmic procedures (Romberg and Carpenterg, 1986) and the diametrically opposing vision of mathematics teaching put forth in the Standards (1989), it seems reasonable to assume that a staff development plan should try to move the teaching of mathematics at this level to a more conceptually oriented perspective.

In this view children would have the opportunity to explore various different ways of solving a problem (including using non-standard but correct algorithms), make guesses, check the validity of their ideas and generally take an active role in the construction of their own knowledge. The teacher would need to structure experiences for the children so that they would be able to eventually come up with the requisite skills with respect to

computation and so on; however, the intent would be to remove the teacher from the position of being the ultimate arbiter of knowledge and to empower the children with the processes to generate their own knowledge. Guided discovery, discussion, conflict resolution, the solving of non-routine problems, and the use of concrete materials would play a significant role in the learning and teaching process.

Although there is evidence that such teaching is possible (Lampert, 1986) it is definitely not common. Unfortunately, it is still true that this view of teaching and learning mathematics is very different from the view that most teachers have been exposed to in their 10,000 hour "apprenticeship of observation" (Lortie, 1975). Surveys show that although a significant proportion of teachers use some manipulatives in first grade, after second grade these materials are used less and less as the children progress through school (Suydam, 1984). And, although most teachers, when asked, claim to believe in the importance of manipulatives this belief does not always translate itself into classroom practice. Furthermore, many elementary teachers do not believe that much background knowledge over and above the ability to carry out the fundamental algorithms of arithmetic is necessary for elementary teachers to be able to teach mathematics successfully (Becker, 1986). Clearly the view presented here would require teachers to re-think many aspects of their mathematics instruction and to do so would require a significant change in their knowledge base. Just what that knowledge base should be would be one important consideration for the staff developer.

The Knowledge Base

The knowledge base required for teaching is a broadly conceived one. As Shulman (1987) points out it has many different dimensions: content knowledge, pedagogical knowledge, curricular knowledge, knowledge of learners, pedagogical content knowledge, knowledge of goals and contexts of learning. I think that it would be exceedingly difficult

for a staff developer to address all of these different facets of teacher knowledge and consequently it is in this area that some hard choices need to be made. The question of what to include and what to leave out of a staff development program can be informed by a consideration of what the teacher needs to know and what they already can be reasonably expected to know.

Although many teachers believe that a knowledge of the basic algorithms is sufficient content knowledge to teach mathematics at the elementary level I do not agree that this is the case. The kind of teaching that has been suggested earlier as the goal of staff development requires an understanding of how mathematical knowledge is arrived at and a knowledge of where various kinds of activities are leading in the larger scheme of mathematical thinking. Giving students the freedom to explore is risky because they can end up exploring territory with which the teacher is unfamiliar. It is not necessarily bad for the teacher to sometimes admit ignorance (in fact it can have a positive impact on some aspects of this kind of teaching); however, he or she ought to know, most of the time anyway, whether students' approaches have any likelihood of bearing fruit -- otherwise they cannot adequately direct student efforts. It is, after all, unreasonable to expect students to be able to discover *everything* by the same process of false starts and frustration that mathematicians have used over several thousands of years to come up with the results that we have today.

This need to promote the idea of how mathematical knowledge comes into being and at the same time achieve some kind of efficiency in the learning process requires a lot of expertise on the part of the teacher. To effectively carry out this kind of teaching it is clear that a knowledge of arithmetic algorithms may be a necessary but certainly not sufficient condition.

To suggest, however, that more mathematical content knowledge will solve the problem is overly simplistic. Being taught calculus at the university level in a rote and mechanistic fashion with the emphasis on correct application of rules for differentiation is

unlikely, in my view, to develop the kind of knowledge required for teaching elementary mathematics. Content knowledge alone, although sometimes useful, is not sufficient to develop the kinds of teaching abilities suggested here because in teaching, the content cannot be fully divorced from the pedagogy. Rather, it is the category of knowledge that Shulman calls pedagogical content knowledge that is vital to the development of mathematics teachers. Shulman does not explicate what this kind of knowledge looks like in the case of mathematics and I think that much more work needs to be done in this area. However, by my understanding the distinction between pedagogical knowledge, content knowledge and pedagogical content knowledge could be drawn this way.

If we assume that there are some topics, ideas, or concepts of mathematics that are more amenable to being taught by one particular pedagogical technique or another, such as guided or open ended discovery, inductive logic, experimentation, formal deduction and so on, then the teacher must at least know these different pedagogical techniques in some general way in order to be able to apply them at all (pedagogical knowledge). Furthermore, the teacher must also know the content that he or she wishes the students to learn (content knowledge); and, how to decide which of the various pedagogical approaches to use for which topics and how a particular pedagogical technique fits with the content to be taught (pedagogical content knowledge). This latter knowledge allows the teacher to understand *why* one technique would be better than another and this understanding then informs the decision about which pedagogical approach to use.

I am certain that this last kind of knowledge does not grow automatically out of further study of university level mathematics. Consequently it is not enough to say that elementary teachers don't know enough math -- the problem is that they don't have enough of a certain kind of mathematical knowledge -- knowledge that is specific to the practice of teaching (as opposed to doing) mathematics. The Holmes Report (1986) makes a similar point when they claim that teachers should have more academic preparation in the subject disciplines that they are expected to teach; but, that undergraduate education would also

need to be re-structured in order to serve the purpose of properly preparing people to teach. So what does this discussion say to the staff developer?

It seems reasonable to assume that the other kinds of knowledge that Shulman alludes to are already available to an experienced teacher through curriculum guides, their years of working with children, pre-service courses in child development and so on. Consequently I would argue that the staff developer ought to concentrate on developing the kinds of mathematical thinking and knowledge that do not appear to be readily available in other places. A consideration of how teachers might develop this pedagogical content knowledge leads naturally to a discussion of how teachers come to learn things and how they develop over time.

How Teachers Learn and Develop

An unfortunate implication of the previous discussion is that teachers need to know something that they don't know and that this implication suggests a deficit model of teacher development. Studies of educational innovation by the Rand Corporation show quite clearly that staff development conducted using this kind of assumption was for the most part ineffective (McLaughlin and Marsh, 1979). The tension here between the desire on the part of a school system to change teaching practice by improving teachers' knowledge and the negative perception that such a view leaves with the participants is obvious. The transparency of the problem, however, does not make it any easier to solve.

I believe that there is an important distinction to be made between knowledge that teachers could be rightfully expected to have but don't have (a deficit model), and knowledge that teachers don't have that no one could expect them to have. Certainly if new programs and ways of thinking about teaching mathematics require complete re-conceptualizations of how teaching and learning take place, it is unreasonable to expect practitioners to already be in possession of this knowledge. Therefore it is not necessarily

contradictory to take the perspective that although there is a significant and critical need for the teachers to acquire a new and different knowledge base, this view does not imply that the teachers are in any way deficient. It would be important to communicate this message to the staff in the way that the program was laid out -- for example, having administrators involved in the development activities would help to foster an "we're all in this together" attitude (McLaughlin and Marsh, 1979).

If the staff developer does not accept a deficit model of teacher development then what view does he (or she) hold? One common theory that helps to explain how teachers learn is a stage of concerns model of teacher development (Feiman-Nemser and Floden, 1980; Fuller, 1969). In such a view teachers move through different stages of concern during their careers and the concerns of each stage must be addressed before the next one is considered. These stages are given various labels in the literature, for example, survival, middle stage, and mastery level; but, the ideas inherent in the labels various writers use are very similar.

A beginning teacher is concerned with self and issues of classroom management and day to day survival. At some point (we hope) these issues are no longer the main focus of the teachers' thinking and she (or he) is able to attend to other things such as planning, organizing and lesson delivery. Finally, in the mastery stage, the teacher is able to focus on the needs and achievement of the students. It is important to note that these stages are not mutually exclusive to one another. A teacher in the survival stage is probably concerned about student achievement also; but, it is not the primary focus of his or her thinking. It is the consideration of what is the *fundamental* concern of the teacher that allows a decision to be made about what stage they might be in.

If a group of teachers are at different stages of development then it becomes an important decision on the part of the staff developer whether the program to be designed should be an individualized one or one for the whole staff. A difficulty for the staff developer who is trying to plan a personalized development program (see Hall and Loucks,

1979) is to establish at what stage in their development teachers are at, and, to develop programming that is suitable regardless of his or her stage of development. This task is particularly difficult if there is a concomitant need to satisfy organizational goals.

It is not clear, however, that a personalistic style of staff development ought to be the model that is followed. As Feiman-Nemser points out, the movement from one stage to another is not automatic and to assume that it is confuses the ideas of readiness and motivation. Given the natural tendency in most people to resist change and the long history of stable practices in schools (Cuban, 1984; Sarason, 1982), it is unrealistic to expect teachers to automatically feel the need to modify their practice just because they have become comfortable with the management and organizational realities of teaching.

If the movement from one stage to another is not automatic then it follows that a major goal of any staff development project should be to facilitate this movement. However, the tension between the perceived personal needs of the teacher and institutional goals make it difficult to decide whether the goals of the organization or the goals of the individuals within it should inform the program. Once again the answer is unclear: Those who believe in personalized staff development would argue that organizations are changed by the changes in the individuals within them while scholars who argue for organizational change (Schiffler, 1979) believe that organizations can play a role in the changing of individuals.[1]

It seems clear that although it is important to take factors about the stage at which teachers are at, their prior background, and their attitudes, beliefs and experience into account, it is equally important for a staff developer to understand that school systems *are*

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[1]In fact,both positions probably have some validity. As the Holmes Report (1986) correctly points out, changes in the workplace conditions of teachers must accompany attempts to change classroom practice. For example, if a school district is committed to the narrow goal of raising standardized test scores, then it is unlikely that a major movement towards conceptual teaching will occur. In this case the organizational goals can and do affect individual practice.

bureaucracies and that in organizations like these the interests of individuals can never have more importance than the desires of the group. Although the ideas of personal freedom and individual choice are dear ones for North Americans, the fact still remains that we all give up some of our personal freedoms to ensure that society as a whole can function. In organizations, such as school systems, it is reasonable to assume that individual teachers would be willing to accept some limits on their own personal freedom and choice if these restrictions resulted in an overall benefit to the system and ultimately to themselves.

Such acquiesence to the needs of the group is only likely if the benefits are clear, or at least plausible. Consequently it is one of the functions of the staff developer to ensure that participants see the value of the program and how it can help to improve instruction and learning. Indeed some scholars suggest that the potential for change in beliefs and attitudes about teaching (and hence permanent changes in practice) comes *after* teachers implement new methods and see the benefits for their students (Guskey, 1986). The assumption here seems to be that the teachers should be somehow compelled to make changes in their practice in order to be able to see this improvement in student performance, otherwise the teacher would never be aware of the potential payoff of the new methodology. In spite of the troublesome idea of forcing people to do things, there is some logic to such a position. For one thing, teachers do derive psychic rewards from seeing their students succeed (Lortie, 1975). Second, the Rand studies did not find that projects instigated by teachers, presumably because of their own perceived needs, were any more successful than those originated by others. What did matter was how the project planning was carried out and the extent to which the influence of organizational factors was included in the plan (McLaughlin and Marsh, 1979).

Despite the lack of consensus on ways to move teachers along to the next higher stage and whether a personal needs model or an organizational needs model should be adopted, it is still important for the staff developer to understand the stage at which the program participants are at. People who are still in the survival stage are unlikely to benefit

from the same kinds of instruction and discussion as teachers who are at the mastery stage. McLaughlin and Marsh (1979) explain the fact that teacher experience was negatively correlated with the success of development programs by this differential interest. In their view, programs designed for less experienced teachers (often the case with typical professional development activities) caused older and more experienced teachers to turn-off and ignore what was being discussed. A development plan needs to take this problem into account and the developer might be well advised to try the development plan with a reasonably homogeneous group of experienced teachers, at least in the early stages.

Even if we assume that we do have such a group with which to work, the precise way that the development plan is conducted will have a huge impact on its potential for success. When trying to change the way that teachers think about teaching mathematics it is necessary to first produce a kind of cognitive dissonance with their previously held understandings. Strike and Posner (1985) hold a conceptual change view of learning that employs this idea. The notion is that learners will take ideas that do not fit into their previously held perspectives and, after a period of conflict caused by trying to make the new ideas fit the old theory, they will adapt their old understandings to incorporate the new ideas. To do so means that teachers have to be taken through a series of experiences that do, in fact, produce intellectual conflict and cause them to re-assess their previously held beliefs.

Such plans have been used successfully in other disciplines. Apelman, Hawkins and Morrison (1985) describe precisely such a summer learning project in the area of science. As in the case of mathematics, many elementary teachers have a weak background in science and hold many naive conceptions about scientific phenomena such as the production of light and colour. In working through a series of well designed experiences designed to challenge these notions, teachers not only learned some science (content knowledge), they also learned about how to teach science (pedagogical knowledge). Furthermore, they came to understand how children would be frustrated by certain aspects of the experiments that

they themselves had done and ways of addressing those frustrations within a lesson context (pedagogical content knowledge). They also came to understand the value of this frustration and how it was a normal part of discovering scientific principles. In other words the project not only changed the way that teachers understood and were able to teach science, it changed the way that they thought about how science ought to be done. Alternatively, Anderson and Smith (1985) suggest that reading case studies of classroom teaching, observing videotapes in which conceptual change teaching of science is practised and, providing teachers with well developed curriculum materials can aid in changing teaching practice to a conceptual change -- as opposed to a didactic -- model.[2]

In spite of the apparent success of such approaches it is important for a staff developer to be sensitive to the potentially destructive effects of this kind of plan. The title of Ruarke's classic novel, Something of Value, which deals with the disintegration of traditional African lifestyles and the Mau Mau uprising in Kenya, has in its frontspiece a Basuto proverb: "If a man does away with his traditional way of living and throws away his customs, he had better first make certain that he has something of value to replace them." The wisdom of this folk saying is clear and germane to the discussion here. Just as African tribesmen who had lost their old way of life without gaining access to the white man's world felt adrift and were easy prey for the Mau Mau leaders, teachers who have lost faith in their old methods without gaining access to new ones are likely to feel disillusioned and powerless. If a development program uses the techniques discussed above to produce cognitive dissonance and dissatisfaction in the teacher as a way of motivating them to change, the staff developer must ensure that when the teachers are at this point the program does not come to an end. Teachers must be supported until well after the new

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[2]The Middle Grades Mathematics Project at Michigan State University, which provides text materials complete with teacher scripts as a way of helping give teachers a feel for the kind of classroom interaction that is desirable, is a good example of this kind of approach. It is important to note, however, that teachers were still provided with extensive support as they tried to change their teaching practice.

understandings are in place; otherwise, they are being left with nothing of value. Flashy demonstrations of why present practice is ineffective without follow-up are of no use; and, are probably more harmful than doing nothing.

Organizational Factors

Many of the organizational factors that affect how effective a staff development program is likely to be have already been discussed; however, a number of other aspects of this category of assumptions still need to be pointed out. For one thing, the norms of collegiality within a school have a significant impact on any attempts to change practice through staff development (Little, 1981). A staff that is used to open discussion of ideas and ways of teaching is much more likely to benefit from such a plan than one in which the more typical norms of isolation and lack of teacher talk are present.

Perhaps this result has to do with the need for on-going support for teachers long after they have attended skills training sessions if permanent changes in practice are to occur (McLaughlin and Marsh, 1979). Consequently, in those schools that do have a collegial atmosphere this on-going support might be provided by the other teachers in the school. The importance of norms of collegiality in a school may also explain why mentor teacher plans do not always work as expected because teachers, in general, are not used to giving or receiving advice from other teachers. Such offers are perceived to be pushy by both the giver and the receiver and so the opportunity for a knowledgeable person to help someone who is less skilled by this method can be problematic (Little, 1984). The work of Joyce and Showers (1980) confirms the importance of follow up (coaching) but the troublesome nature of the relationships between teachers that Little alludes to casts some doubt on the value of the peer-coaching model. Still, in a school where open discussion of teaching practices and ideas is the norm this role conflict would be less likely to occur. Not all support was equally valued by teachers though, the Rand Studies found that support

from consultants that was not perceived to be useful or helpful was worse than no support at all.

Another important factor uncovered in the Rand studies was the importance of the level of support for the program that was provided by the school principal. Although temporary effects could be achieved by a well designed program led by an inspirational leader, these effects disappeared in schools where the plan was not supported in a continuing way by the principal in the building. A staff developer would need to consider to what extent the factors that work to promote success are present in the site that is being considered for the project.

A final factor that it is important to be aware of is the sense of teacher efficacy that a staff holds. Once again the Rand studies found that a belief on the part of the teachers that they could make a difference in the classroom was a significant factor in the success of innovations. In some sense I interpret this result to be yet another manifestation of how people react to being powerless versus powerful. Teachers who feel that they can't help kids to learn regardless of what they do feel powerless and unlikely to try anything new. Perhaps this is the same fundamental reason that collaborative goal setting and conceptual clarity about the project were also associated with successful programs. Teachers who felt that they had some power over or influence about what they were being asked to do were more likely to feel a sense of ownership. It is worth mentioning that this sense of teacher efficacy does not appear to be a static and fixed quantity -- the Rand studies provided evidence that well structured staff training sessions coupled with extensive support could change the perceptions of teachers with respect to their sense of efficacy (McLaughlin and Marsh, 1979).

Where Do We Go From Here?

Given the previous discussion, what might a staff development program look like? I would see a series of summer institutes where teachers would actually go through the kind of learning process that is being advocated for their own students as being central to the project. Well developed sequences of materials could serve the dual purpose of teaching the content that was required as well as providing teachers with the chance to see pedagogical modelling of a variety of teaching techniques. Open discussion and feedback would help to alleviate anxiety and work towards changing the teachers' beliefs about mathematics teaching and learning.

Teachers would come to know how mathematical truth could be arrived at and this new mindset would allow for the continuing development of the pedagogical content knowledge base that I have suggested is so important to teaching. Teachers would be supported in their attempts to teach in this new way with credible and competent consultants throughout the upcoming years as they started the process of implementing this new model. Provision for collaborative work between the staff support group and other staff members would be organized rather than left to chance, and, time would be provided for these regular opportunities to discuss and share ideas, experiences and problems.

The staff would be chosen from a school where administrative support both at the building level and the district level was clearly evident. The school would be one where the teachers already worked well as a team and where collegiality was already well established. The project would be presented not as an innovation but as program development and the principal would attend all the summer institutes along with the staff. There would be specific times set aside for discussion among and between participants and organizers in the earliest stages of planning, both as a way of achieving conceptual clarity

about the goals of the project and to allow for ongoing changes to be made in response to teachers' needs and interests.

It would be important to be careful that any changes suggested did not destroy the integrity of the program. To help ensure that goals were followed and teachers were not being coerced, teachers who absolutely could not accept the vision of teaching that the project was putting forth would be permitted to opt out with the option of re-entry at a later date; but, given the ambitious nature of the program and the fact that big projects tend to be accepted more readily than smaller ones (McLaughlin and Marsh, 1979), it is not anticipated that large numbers of teachers would not want to be involved.

Much of what has been written here is not specific to mathematics teaching but for this I offer no apology. Teaching is a social and political act regardless of how apolitical the content might appear to be. As mathematics educators we must not be trapped into believing that a narrow focus on things mathematical will allow us to change the way that mathematics is taught; rather, an understanding of the social world of the teacher must help to inform our design of staff development plans.

I do not pretend that a plan such as the one that I have described represents the only way to structure staff development programs -- it is only an attempt to suggest some possibilities. Neither do I suggest that it would be easy or that it would be cheap -- it would be neither. However, the evidence is quite clear that the kinds of inexpensive, quick and easy development plans that have often been the norm in the past simply do not work. The writer George Santayana is credited with saying "Those who do not remember the mistakes of the past are condemned to repeat them." In designing staff development programs to complement the vision of mathematics teaching that the Standards (1989) imply we *must* remember the mistakes of the past. Change of the revolutionary kind proposed by the Standards (1989) should not be expected to be cheap; but, in staff development as in all things you do get what you pay for.

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